JOURNAL OF ANIMAL SCIENCE
The Premier Journal and Leading Source of New Knowledge and Perspective in Animal Science

Behavioral sampling techniques for feedlot cattle

F. M. Mitlohner, J. L. Morrow-Tesch, S. C. Wilson, J. W. Dailey and J. J. McGlone

J Anim Sci 2001. 79:1189-1193.

Behavioral sampling techniques for feedlot cattle[1,2]

F. M. Mitlöhner*, J. L. Morrow-Tesch†, S. C. Wilson*, J. W. Dailey†, and J. J. McGlone*,[3]

*Department of Animal Science & Food Technology, Texas Tech University, Lubbock 79409-2141 and †USDA-ARS, Livestock Issues Research Unit, Lubbock, TX 79409-2141

ABSTRACT: Continuous observations are an accurate method for behavioral measurements but are difficult to conduct on large numbers of animals because of extensive labor requirements. Thus, we sought to develop methods of behavioral data collection in feedlot cattle production systems that reasonably approximated continuous sampling. Standing, lying, feeding, drinking, and walking behaviors were examined from 224 h of continuous video from 64 heifers. Experiment 1 (n = 24 heifers) compared continuous behavioral sampling techniques (Continuous) with scan sampling using intervals of 1, 5, 10, 15, 30, and 60 min and time sampling (a technique for the periodic recording of behavior) for the first 10 min out of every 60 min. Means for each scan sampling method did not differ in estimated percentage of duration of behaviors ($P > 0.05$) from continuous sampling, except for scan sampling with a 60-min interval. Scan sampling with a 60-min interval differed from more frequent scan sampling intervals for all behaviors except lying. Scan sampling with short intervals (1 and 5 min) was correlated highly with Continuous for all behaviors. The longer the scan interval, the lower the correlations, especially for behaviors with short duration. Time sampling was not an accurate technique for measuring the sampled behaviors. Focal animal sampling (using continuous sampling of individuals) indicated that one heifer was representative of the entire pen of 10 animals (Continuous) for all maintenance behaviors except drinking. Scan sampling methods (1-, 5-, 10-, and 15-min intervals) were accurate methods of behavioral sampling for feedlot cattle, but scan intervals of 30 or 60 min were less accurate and less precise. Time sampling was not an accurate method because it overestimated standing and underestimated lying behaviors. Experiment 2 (n = 40 heifers) investigated the number of focal animals required to accurately represent continuous behavioral sampling for all animals. Focal animal sampling was accurate for most behaviors using as few as 1 animal out of 10 but was not an accurate method for drinking behavior unless 40% of the animals in the pen were observed. Estimates of sample sizes needed for experimental protocols are provided. Behavioral means, standard deviations, and coefficients of variation are presented along with estimates of required sample sizes. These results validate accurate, precise, and efficient methods for quantifying feedlot cattle behavior.

Key Words: Behavior, Cattle, Feedlots, Sampling Techniques

 J. Anim. Sci. 2001. 79:1189–1193

Introduction

Physiological analyses that seek to quantify animal responses must be validated in the laboratory to ensure that appropriate conclusions can be drawn from the data. Behavioral observations also are a type of "assay" that is used to quantify animal biological responses. As with physiological measurements, methods of behavioral observation should be validated and selected based on the objectives of the particular study. The limitations and advantages of different types of observational sampling methods of animal behavior have been examined by Altmann (1974), Arnold-Meeks and McGlone (1986), Martin and Bateson (1993), and Lehner (1996). These techniques have been discussed with regard to a range of animal species such as mice, swine, and primates; however, there have been no studies of this nature conducted on cattle maintained under feedlot conditions. Sampling cattle behaviors under feedlot conditions demands a high degree of labor, equipment, and time. Large numbers of animals per pen (the usual experimental unit) makes it difficult to sample the entire population continuously.

[1]The authors thank Cathy Dobbs, Barbara Rothengass, Kirk Robinson, and Ricardo Rocha for their technical assistance during the study. This study was supported by a specific cooperative agreement 58-3602-6-101 between Texas Tech Univ. and USDA-ARS. Texas Tech Univ. manuscript number T-5-390.

[2]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the United States Department of Agriculture or the Agricultural Research Service of any product or service to the exclusion of others that may be suitable.

[3]Correspondence: E-mail: john.mcglone@ttu.edu.

Received September 21, 2000.
Accepted January 29, 2001.

Therefore, alternative sampling techniques for the conditions of the feedlot environment need to be selected. The most widely used technique for behavioral observations of cattle is scan sampling (Ray and Roubicek, 1971; Kondo et al., 1983; Gonyou and Stricklin, 1984), although this method has not been validated for use in a feedlot situation. The objectives of our studies were 1) to compare and validate scan sampling and time sampling with continuous sampling, 2) to determine the number of focal animals required to represent the entire population of animals for maintenance behaviors, and 3) to estimate sample sizes required for feedlot cattle behavior research.

Materials and Methods

General

Studies were conducted at the Texas Tech University's experimental feedlot in New Deal, TX. Animals were housed and used in accordance with the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* (FASS, 1999), and Texas Tech University Animal Care and Use Committee approved the project.

Animals

In Exp. 1, 24 Charolais-cross heifers, approximately 10 to 12 mo of age, were assigned randomly to 12 groups of two animals per pen. Concrete pens with partially slatted floors were used with a space allowance of 9 m^2/heifer. Feed was a 90% concentrate diet, fed once daily (1000), and water was available at all times.

For Exp. 2, 40 Charolais-cross heifers, 10 to 12 mo old, were allocated randomly into four pens (10 animals/pen). Pens were dirt floored with a stocking density of 50 m^2/heifer. The heifers were bunk-fed a 90% concentrate diet once a day (1000) and had free access to the feed and water.

Behavior

In both experiments maintenance behaviors (standing, lying, feeding, drinking, and walking) were recorded. Standing was considered to be an inactive upright posture (no locomotion), whereas lying was defined as body contact with the ground. Feeding was defined to be head over or in the bunk, and drinking as the head over or in the water trough. Walking was defined as any change of body location within the pen. Behaviors were recorded in normal speed (30 frames/s) with a video system (Panasonic camera Model WV-CP412 and Panasonic video cassette recorder Model 6730).

Experiments

Exp. 1: General Methods. Each animal in Exp. 1 was filmed for 6 h composed of three 2-h blocks. Each 2-h block was filmed at different times and days in September 1998. For example, Animal 1 was observed from 1000 to 1200 on d 1, 1200 to 1400 on d 2, and 1400 to 1600 on d 3. This procedure prevented time-specific behaviors (e.g., lying) from dominating the dataset and provided raw data that represented different levels of activity. A total of 144 1-h observations were conducted, and these constituted the database. The acquisition of continuous data for both experiments was conducted by one trained person who viewed (30 frames/s) and entered the data from videotapes into the computer using the Observer software (Noldus, The Netherlands).

Continuous Sampling. Martin and Bateson (1993) define continuous sampling as being an "exact and faithful record of the behavior, measuring true frequencies and durations and the times at which behavior patterns stopped and started." Continuous sampling is the continuous recording of the behaviors an animal performs at any given time. In both experiments, continuous sampling (**Continuous**) was the control for validating the other sampling techniques. Tapes were reviewed at the speed at which they were recorded (30 frames/s).

Scan Sampling. Scan sampling describes which behavior an animal (or a group of animals with each animal in turn) exhibits at a fixed time interval (Colgan, 1978). In Exp. 1 continuous data were used to create the scan sample data set. Selected data points within the continuous data set were extracted and used to create a scan sample data set (i.e., every 60th second was used to create the scan sample for a 1-min interval). Behaviors were analyzed at scan intervals of 1, 5, 10, 15, 30, and 60 min.

To represent behavior over an entire hour, scan samples were multiplied by the appropriate factor (1-min data were multiplied by 60, 5-min data by 12, and so on). Durations (per hour) of each behavior were converted to a percentage of the total time, and these percentages were then square root-arcsine transformed to achieve normal distribution. Transformed data were analyzed using the General Linear Model in SAS (SAS Inst. Inc., Cary, NC). The treatments were the individual sampling techniques: continuous and scan sampling. The model included animal, pen, treatment, and the treatment × animal interaction. The error term treatment × animal was used to test treatment effects. Residual error was used to test all other effects. Two-tailed t-tests were used to separate treatment means following a significant overall F-test. Pearson product correlations (SAS Inst. Inc.) were used to correlate duration of behavior from scan samples with continuous observations.

Time Sampling. In time sampling, only a portion of the total behavioral observation time is recorded (Arnold-Meeks and McGlone, 1986). In Exp. 1, the duration (s) of the behaviors within the first 10 min of each hour were continuously measured and the average was then multiplied by 6. These data were then correlated to averages of the continuous 1-h sampling. The least squares means and standard deviations of the transformed (square root-arcsine transformation) data were calculated using GLM procedure. Again, Pearson product cor-

Table 1. Least squares means[a], standard errors, and P-values for percentages of maintenance behaviors of 24 Charolais-cross cattle under feedlot conditions measured with different sampling techniques (values are percentage of the total duration for 2 h)

	Sampling method									
		Scan samples, minute-intervals between scans								
Behavior	Continuous sample	1	5	10	15	30	60	Time sample, 10 min/h	SE	P-value
Standing	13.26[b]	13.44[b]	13.39[b]	12.27[b]	12.50[b]	15.62[b]	20.49[c]	19.89[c]	1.23	0.001
Lying	71.93[b]	72.04[b]	72.16[b]	73.73[b]	72.83[b]	74.65[b]	73.96[b]	65.40[c]	1.34	0.001
Feeding	10.0[b]	9.97[b]	10.36[b]	10.36[b]	10.68[b]	8.33[bc]	5.55[c]	10.05[bc]	1.12	0.027
Drinking	0.91[bc]	0.94[bc]	1.07[b]	1.22[b]	0.87[bc]	0.35[bc]	0.00[d]	0.94[bc]	0.27	0.034
Walking	3.90[b]	3.61[b]	3.07[b]	2.43[bc]	3.13[b]	1.04[c]	0.00[d]	3.7[b]	0.51	0.001

[a]Least squares means are presented as untransformed means. Analyses were on transformed data. SE is the pooled standard error of the least squares means.
[b,c,d]Least squares means with different superscripts differ (P < 0.05).

relations were used to correlate duration of behavior for time sampling vs Continuous.

Exp. 2: General Methods. In Exp. 2, 40 heifers were filmed over 2 h (from 1000 to 1100 and from 1300 to 1400 h) on the same day. The video recorder filmed at 30 frames/s. Heifers were fed and housed as described previously.

Focal Sampling. Focal sampling is the random selection of one or a few animals out of a population with the continuous recording of their behaviors. These samples are intended to represent the behaviors of the entire group (Jensen et al., 1986). To determine the number of focal animals needed to represent the behavior of an entire group of 10 animals, the video records were analyzed for 10 individual animals. Percentage of duration of each behavior (of one to nine animals) was compared to the total group of 10 animals. The data were square root-arcsine transformed, and least squares means and standard errors were calculated using GLM procedure. Least squares means were compared using the predicted difference test within the LSMEANS option of GLM.

Sample Size Estimates. Before studies are initiated, it is prudent to estimate the number of replications (N) required to detect an expected difference among means. We conducted basic Student's t-tests, using the standard deviation estimated from continuous data collection, to estimate the N required. The P-value was set at 0.05 and differences among means were set at 10, 25, and 50% (treatment vs control). Calculations were performed using either the animal or the pen as the experimental unit because of different standard deviations for pen- or animal-based measurements.

Results

Scan and Time Sampling: Comparison of Means. Table 1 shows the least squares means, standard errors, and probabilities for behaviors comparing different sampling techniques. Means for scan sampling with scan intervals of 1, 5, 10, or 15 min were similar to Continuous for all behaviors. A scan interval of 30 min was similar to all behaviors except walking (P < 0.001). Most scan methods determined the time spent lying and standing accurately and were not different from Continuous. The only exception was scan sampling, using the 60-min interval, which not only differed from Continuous for standing behavior (P < 0.001), but also for feeding, drinking, and walking (P < 0.05). Comparison of least squares means for time sampling with Continuous showed significant differences for means of standing and lying behavior. Time sampling overestimated standing (P < 0.01) and underestimated lying (P < 0.01) behavior. Percentage of time spent drinking, feeding, and walking were similar between time sampling and Continuous (P > 0.05).

Scan and Time Sampling: Correlations. Correlations between scan and time sampling with Continuous are presented in Table 2. Behaviors measured with 1-min scan samples were highly correlated with Continuous (r > 0.97; P < 0.01). For standing, lying, and feeding behaviors scan sampling measured in 5- and 10-min intervals correlated moderately (r > 0.82; P < 0.01) with Continuous. Correlations between the 15-min scan and Continuous were moderate for standing and lying behaviors (r > 0.83; P < 0.01). Scan sampling for 5, 10, and 15 min correlated moderately with Continuous for drinking and walking (r < 0.80; P < 0.01). For these behaviors (drinking and walking) scan sampling at 30-min intervals and Continuous showed a low correlation (r < 0.36; P < 0.01) and scan sampling with a 60-min interval was inestimable because scans were zero (behaviors were not recorded during the scan moments). Low correlations also were found between time sampling and Continuous for all behaviors (r < 0.63; P < 0.01).

Focal Animal Sampling: Comparison of Means. The five behaviors were compared between one through nine focal animals and the total of 10 heifers per pen (Table 3). For all behaviors, no differences in percentage of time were found for four to nine focal animals compared with that of 10 heifers. Percentage of time for drinking behavior was different (P < 0.01) for one to three focal animals compared with means for 10 heifers per pen.

Sample Size Estimates. Estimate of means, standard deviations, coefficients of variation (CV), and replica-

Table 2. Correlation coefficients of behavioral sampling techniques compared to continuous sampling

Behavior	Sampling method: Scan samples, minute-intervals between scans 1	5	10	15	30	60	Time sampling, 10 min/h
Standing	0.996**	0.946**	0.873**	0.837**	0.710**	0.573**	0.627**
Lying	0.999**	0.991**	0.973**	0.932**	0.778**	0.485**	0.542**
Feeding	0.997**	0.941**	0.824**	0.761**	0.581**	0.175*	0.464**
Drinking	0.984**	0.744**	0.673**	0.394**	0.358**	NE[a]	0.502**
Walking	0.971**	0.686**	0.502**	0.374**	0.104	NE[a]	0.503**

[a]These r-values were not estimable (NE) because all scans of these behaviors were zero and thus there was no variation. An infrequent scan would not be expected to pick up infrequent behaviors.
N = 144 observations.
*Significant effect at $P < 0.05$ (r > 0.17); **$P < 0.01$ (r > 0.23).

tions needed are presented in Table 4. The number of replications required to detect a 10, 25, or 50% difference among means varied from two for lying and feeding with pen as the experimental unit and 25 or 50% difference to 3,600. Drinking and walking required a very large number of replications due to the very high CV values.

Discussion

As with any biological assay, requirements for accurate methods to measure cattle behavior should include a high correlation and a similar mean to some standard. In most behavioral studies the standard is continuous sampling. Continuous all-animal behavioral sampling in beef cattle feedlots is extremely difficult to perform because of the high number of animals per pen (10 to 200) and the low frequency of occurrence and short duration of some behaviors. This study used continuous analysis of behavior for both experiments as the standard to compare to other, less time- and labor-intensive sampling methods.

The results from this study show that scan sampling techniques with relatively short interval lengths (1, 5, 10, or 15 min) were accurate and precise for measuring durations of standing, lying, and feeding behaviors but were less precise for drinking and walking behaviors. Scan sampling techniques with long intervals (e.g., 30 or 60 min) were generally neither accurate nor precise for measuring behaviors with short durations. Scan sampling with a 60-min interval was an inappropriate sampling technique for behaviors because it lacked accuracy and precision in predicting Continuous. These findings support the conclusions of Jensen et al. (1986) and Martin and Bateson (1995) that scan sampling methods can provide an unbiased estimate of percentage of time of the behavior studied when the scan interval is short enough relative to the duration of the behavior being studied and enough animals are sampled.

Several authors have used scan sampling with broader intervals to measure behavior in feedlot cattle. Ray and Roubicek (1971) recorded feeding, drinking, and walking using 1-h intervals. In a feedlot cattle behavior study, Gonyou and Stricklin (1984) also performed scan sampling at a 1-h interval for standing, lying, feeding, and drinking in one trial but Continuous for standing, lying, eating, drinking, licking and scratching (self), cross-

Table 3. Means and standard errors for percentages of behaviors when comparing all animals vs subsamples of focal animals using the *t*-test

Number of focal animals	Behavior: Standing	Lying	Feeding	Drinking	Walking
All animals (n = 10)	23.35 ± 3.52	46.95 ± 6.19	21.16 ± 4.02	2.14 ± 0.96	6.40 ± 0.97
9	23.91 ± 3.77	48.07 ± 6.52	18.95 ± 3.80	2.38 ± 1.06	6.68 ± 1.06
8	25.38 ± 4.10	45.08 ± 6.86	20.13 ± 4.11	2.64 ± 1.19	6.77 ± 1.09
7	24.48 ± 4.15	44.42 ± 7.21	21.14 ± 4.49	2.79 ± 1.36	7.17 ± 1.21
6	23.64 ± 4.56	46.71 ± 7.59	21.62 ± 5.06	2.00 ± 1.14	6.03 ± 0.84
5	25.33 ± 5.32	43.26 ± 8.36	22.78 ± 5.37	2.33 ± 1.36	6.30 ± 0.88
4	27.12 ± 6.31	42.37 ± 9.49	22.69 ± 6.44	1.46 ± 1.03	6.36 ± 0.99
3	23.63 ± 6.42	45.97 ± 10.53	23.80 ± 7.85	0.14 ± 0.01**	6.46 ± 1.18
2	27.52 ± 8.79	40.17 ± 13.05*	24.65 ± 10.55	0.21 ± 0.14**	7.46 ± 1.35
1	26.06 ± 13.11	35.31 ± 20.81	29.84 ± 18.87	0.17 ± 0.17**	8.61 ± 1.76

*$P < 0.05$.
**$P < 0.01$.

Table 4. Mean values (% of observations), standard deviations (SD), coefficient of variation (CV, %) and numbers of experimental units (EU) required when either the animal or the pen is the EU. Data are based on continuous observations. Sample size estimates are based on assumptions that may differ among studies. When the estimated number of replicates was less than 2, then a value of 2 was entered into the table

						Replications needed					
		Animal EU		Pen EU		Animal EU To detect a mean difference of:			Pen EU To detect a mean difference of:		
Behavior	Mean	SD	CV	SD	CV	10%	25%	50%	10%	25%	50%
Standing	14.8	18.1	122.7	6.7	49.1	935	150	37	128	20	5
Lying	70.0	28.9	41.4	7.4	10.4	107	17	4	7	2	2
Feeding	10.1	13.7	134.9	1.3	12.8	1,150	184	46	10	2	2
Drinking	1.0	2.4	263.3	0.8	81.1	3,600	576	144	400	64	16
Walking	4.2	5.7	134.9	2.2	54.8	1,151	184	46	171	27	7

grooming, and engaging in agonistic behaviors in a second trial. Our results indicate that the scan sampling technique with intervals of not more than 15 min was accurate for behaviors with long duration (lying, standing, and also feeding); however, behaviors with short duration (walking or drinking) had low correlations with the Continuous methods. Scan samples of 30 or 60 min are only suitable for measuring lying behavior of feedlot cattle.

Time sampling demonstrated unacceptably low correlations for all behaviors with Continuous when pens were sampled for 10 min/h. Similar findings have been reported in pigs (Arnold-Meeks and McGlone, 1986). Using time sampling with a 10-min period, one could observe six animals or pens of animals per hour. In that same time, many more pens could be observed with greater accuracy using scan sampling, thereby allowing collection of more experimental units per hour at a greater accuracy than with time sampling.

The number of focal animals that represented the entire pen of 10 animals accurately for feeding, standing, and lying behaviors was as few as 1 animal out of 10. Thus, by observing 1 animal per 10, one can accurately record certain behaviors of the group of animals. For drinking behavior, which has a short duration and high individual variation, at least 4 focal animals out of 10 were required to get an accurate representation of all animals in the pen.

To assist future investigators, we calculated the minimum number of replications needed for sampling cattle behavior in the feedlot environment (Table 4). The number of replicates depends on many factors, including the difference in treatment means expected, the variation, and whether the experimental unit (**EU**) is the animal or the pen. From the data in Table 4 it is clear that the number of EU needed was much greater when the animal was the EU because the variation among animals was much higher than the variation among pens of feedlot cattle (note SD in Table 4). For infrequent behaviors such as drinking and walking, the number of replications needed to detect a meaningful biological difference is quite high and use of methods other than those reported here might be required to obtain useful information. If the assumptions we used vary, then the estimates of sample size would vary, too. Animal care and use committees could use these estimates of required sample size as a first approximation.

Implications

Each behavioral sampling technique has specific strengths and weaknesses and must be carefully selected based on the objectives of the particular study. Scan sampling with an interval of 10 min or less will effectively represent feedlot cattle behaviors examined. Focal animal sampling was an acceptable technique only for behaviors of long duration (e.g., feeding and lying). Time sampling is unacceptable in accuracy for most behaviors. Scientists using behavior to accept or reject null hypotheses should include a validation of their “behavioral assay” to ensure proper collection and interpretation of the data.

Literature Cited

Altmann, J. 1974. Observational study of behavior: Sampling methods. Behaviour 49:227–267.

Arnold-Meeks, C. A., and J. J. McGlone. 1986. Validating techniques to sample behavior of confined, young pigs. Appl. Anim. Behav. Sci. 16:149–155.

Colgan, P. W. 1978. Quantitative ethology. Wiley, New York.

FASS. 1999. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. 1st rev. ed. Federation of Animal Sciences Societies, Savoy, IL.

Gonyou, H. W., and W. R. Stricklin. 1984. Diurnal patterns of feedlot bulls during winter and spring in northern latitudes. J. Anim. Sci. 58:1075–1083.

Jensen, P., B. Algers, and I. Ekesbo. 1986. Methods of Sampling and Analysis of Data in Farm Animal Ethology. Birkhäuser, Basel, Switzerland.

Kondo, S., N. Kawakami, H. Kohama, and S. Nishino. 1983. Changes in activity, spatial pattern and social behaviour in calves after grouping. Appl. Anim. Ethol. 11:217–228.

Lehner, P. N. 1996. Handbook of Ethological Methods. Cambridge University Press, Cambridge, U.K.

Martin, P., P. Bateson. 1993. Measuring Behaviour. Cambridge University Press, Cambridge, U.K.

Ray, D. E., and C. B. Roubicek. 1971. Behavior of feedlot cattle during two seasons. J. Anim. Sci. 33:72–76.